Claims

[c1] 1.A flexible interconnect structure comprising:
a flexible dielectric film having two opposed surfaces, at least a portion of said dielectric film being removed through a thickness thereof, forming at least a removed portion;
circuit traces disposed on at least one of said surfaces; and
at least a heat sink being attached to a surface of said dielectric film, said at least a heat sink covering said at least a removed portion.

[c2] 2. The flexible interconnect structure of claim 1, wherein said dielectric film comprises a flexible material that provides electrical isolation across a thickness of said dielectric film, said material being selected from the group consisting of thermoplastic polymers, acrylic resins, polyester, polyimide, and polyetherimide.

[c3] 3.The flexible interconnect structure of claim 1, wherein said dielectric film has a thickness in a range from about 1 micrometer to about 5 mm.

[c4] 4.The flexible interconnect structure of claim 1 further comprising at least one electrical circuit component selected from the group consisting of resistors, capacitors, inductors, integrated circuits, and power sources.

[c5] 5.The flexible interconnect structure of claim 4 further comprising a dielectric protective layer disposed to cover said electrical circuit components and circuit traces.

[c6] 6.The flexible interconnect structure of claim 1, wherein said at least a heat sink comprises a thermally conductive material.

[c7] 7.The flexible interconnect structure of claim 6, wherein said thermally conductive material is selected from the group consisting of metals and ceramics.

[c8] 8.The flexible interconnect structure of claim 1, wherein said at least a heat sink has fins extending away from said dielectric film.

[c9] 9.The flexible interconnect structure of claim 1, wherein said heat sink comprises heat pipes to carry heat away from an electrical component disposed thereon.

[c10] 10.The flexible interconnect structure of claim 1, wherein said heat sink comprises a mechanism for active cooling.

[c11] 11.The flexible interconnect structure of claim 10, wherein said active cooling is effected by a mechanism selected from forced cooling, refrigeration, and heat transport by Peltier effect.

[c12] 12.The flexible interconnect structure of claim 1, wherein said at least a heat sink covers a plurality of said removed portions.

[c13] 13.The flexible interconnect structure of claim 1, wherein said at least a heat sink comprises a body made of a material selected from the group consisting of metals and ceramics, said body covering substantially an entire surface of said dielectric film opposite to a surface on which circuit traces are disposed.

[c14] 14.A flexible interconnect structure comprising:
(a)a multilayer stack comprising:
(1)a plurality of flexible dielectric films, each having two opposed surfaces and supporting at least a circuit on at least a surface of each of said plurality of dielectric films, said circuit comprising circuit traces, circuits supported on said plurality of flexible dielectric films being interconnected by a plurality of vias; and
(2)an electrically insulating layer disposed between a pair of said flexible dielectric films to separate circuits supported thereon;
wherein at least a portion of said multilayer stack is removed through an entire thickness of said multilayer stack to form at least a removed portion devoid of circuit traces;
(b)at least a heat sink being attached to an outer surface of said multilayer stack, said at least a heat sink covering said at least a removed portion.

[c15] 15.The flexible interconnect structure of claim 14, wherein each of said plurality of said flexible dielectric films comprises a flexible material that provides

electrical isolation across a thickness of said dielectric film, said material being selected from the group consisting of thermoplastic polymers, acrylic resins, polyester, polyimide, and polyetherimide.

[c16] 16.The flexible interconnect structure of claim 14, wherein each of said dielectric films has a thickness in a range from about 1 micrometer to about 5 mm.

[c17] 17.The flexible interconnect structure of claim 14 further comprising at least one electrical circuit component selected from the group consisting of resistors, capacitors, inductors, integrated circuits, and power sources disposed on at least one of said dielectric films.

[c18] 18.The flexible interconnect structure of claim 14 further comprising a dielectric protective layer disposed to cover exposed electrical circuit components and circuit traces.

[c19] 19.The flexible interconnect structure of claim 14, wherein said at least a heat sink comprises a thermally conductive material.

[c20] 20.The flexible interconnect structure of claim 19, wherein said thermally conductive material is selected from the group consisting of metals and ceramics.

[c21] 21.The flexible interconnect structure of claim 14, wherein said at least a heat sink has fins extending away from said dielectric film.

[c22] 22.The flexible interconnect structure of claim 14, wherein said heat sink comprises heat pipes to carry heat away from an electrical component disposed thereon.

[c23] 23.The flexible interconnect structure of claim 14, wherein said heat sink comprises a mechanism for active cooling.

[c24] 24.The flexible interconnect structure of claim 23, wherein said active cooling is effected by a mechanism selected from forced cooling, refrigeration, and heat transport by Peltier effect.

[c25] 25.The flexible interconnect structure of claim 14, wherein said at least a heat sink covers a plurality of said removed portions of said multilayer stack.

[c26] 26.The flexible interconnect structure of claim 14, wherein said at least a heat sink comprises a body made of a material selected from the group consisting of metals and ceramics, said body covering substantially an entire outer surface of said multilayer stack.

[c27] 27.An electrical device comprising:

(a) a flexible interconnect structure that comprises:

(1) a flexible dielectric film having two opposed surfaces, at least a portion of said dielectric film being removed through a thickness thereof, forming at least a removed portion;

(2)circuit traces disposed on at least one of said surfaces; and

(3)at least a heat sink being attached to a surface of said dielectric film, said at least a heat sink covering said at least a removed portion and being electrically isolated from at least one of said circuit traces; and

(b)at least a light-emitting element selected from the group consisting of light-emitting diode ("LED"), laser diode ("LD"), and combinations thereof, said at least a light-emitting element being attached to said at least a heat sink in thermal contact therewith through said removed portion, said at least a light-emitting element being electrically connected to said circuit traces.

[c28] 28.The electrical device of claim 27, wherein said at least a light-emitting element is disposed in a reflective cup that is attached to said at least a heat sink in thermal contact therewith through said removed portion.

[c29] 29.The electrical device of claim 27, wherein said reflective cup contains a mixture of a substantially transparent resin and at least a photoluminescent material that is capable of absorbing a portion of a first electromagnetic ("EM") radiation emitted by said LED and converting said portion of said first EM radiation to a second EM radiation having a different wavelength range.

[c30] 30.The electrical device of claim 27 further comprising at least an electrical circuit component supported on said flexible dielectric film, said circuit

component being selected from the group consisting of resistors, capacitors, inductors, integrated circuits, and power sources.

[c31] 31.The electrical device of claim 27, wherein said dielectric film comprises a flexible material that provides electrical isolation across a thickness of said dielectric film, said material being selected from the group consisting of thermoplastic polymers, acrylic resins, polyester, polyimide, and polyetherimide.

[c32] 32.The electrical device of claim 27, wherein said dielectric film has a thickness in a range from about 1 micrometer to about 5 mm.

[c33] 33.The electrical device of claim 27 further comprising a dielectric protective layer disposed to cover said electrical circuit components and circuit traces.

[c34] 34.The electrical device of claim 27, wherein said at least a heat sink comprises a thermally conductive material.

[c35] 35.The electrical device of claim 34, wherein said thermally conductive material is selected from the group consisting of metals and ceramics.

[c36] 36.The electrical device of claim 27, wherein said at least a heat sink has fins extending away from said dielectric film.

[c37] 37.The electrical device of claim 27, wherein said heat sink comprises heat pipes to carry heat away from an electrical component disposed thereon.

[c38] 38.The electrical device of claim 27, wherein said heat sink comprises a mechanism for active cooling.

[c39] 39.The electrical device claim 38, wherein said active cooling is effected by a mechanism selected from forced cooling, refrigeration, and heat transport by Peltier effect.

[c40] 40.The electrical device of claim 27, wherein said at least a heat sink covers a plurality of said removed portions.

[c41] 41.The electrical device of claim 27, wherein said at least a heat sink comprises

a body made of a material selected from the group consisting of metals and ceramics, said body covering substantially an entire surface of said dielectric film opposite to a surface on which said circuit traces are disposed.

[c42] 42.An electrical device comprising:

(a)a multilayer stack comprising:

(1)a plurality of flexible dielectric films, each having two opposed surfaces and supporting at least a circuit on at least a surface of each of said plurality of dielectric films, said circuit comprising circuit traces, circuits supported on said plurality of flexible dielectric film being interconnected by a plurality of vias; and

(2)an electrically insulating layer disposed between said flexible dielectric films to separate circuits supported thereon;

wherein at least a portion of said multilayer stack is removed through an entire thickness of said multilayer stack to form at least a removed portion devoid of circuit traces;

(b) at least a heat sink being attached to an outer surface of said multilayer stack, said at least a heat sink covering said at least a removed portion; and

(c) at least a light-emitting element selected from the group consisting of LED and LD, said at least a light-emitting element being attached to said at least a heat sink in thermal contact therewith through said at least a removed portion, said at least a light-emitting element being electrically connected to at least one of said circuit traces.

[c43] 43.The electrical device of claim 42, wherein said at least a light-emitting element is disposed in a reflective cup that is attached to said at least a heat sink in thermal contact therewith through said at least a removed portion.

[c44] 44.The electrical device of claim 43, wherein said reflective cup contains a mixture of a substantially transparent resin and at least a photoluminescent material that is capable of absorbing a portion of a first EM radiation emitted by said light-emitting element and converting said portion of said first EM radiation to a second EM radiation having a different wavelength range.

[c45] 45.A method for making an electrical device that comprises at least a light-

emitting element selected from the group consisting of LED and LD, said method comprising:

(a)providing a flexible dielectric film having a first surface and a second surface;

(b)disposing circuit traces on at least one of said surfaces;

(c)removing at least a portion of said dielectric film through a thickness thereof to form at least a removed portion that is devoid of said circuit traces;

(d)attaching at least a heat sink to one of said surfaces of said flexible dielectric film, said heat sink covering said at least a removed portion and being electrically isolated from at least one of said circuit traces; and

(e)attaching said at least a light-emitting element to said at least a heat sink through said removed portion so that said at least a light-emitting element is in thermal contact with said heat sink.

[c46] 46.The method for making an electrical device according to claim 45, wherein said attaching said at least a light-emitting element comprises disposing said at least a light-emitting element in a reflective cup and attaching said cup to said at least a heat sink.

[c47] 47.The method for making an electrical device according to claim 45 further comprising making electrical connections between said at least a light-emitting element and at least one of said circuit traces.

[c48] 48.The method for making an electrical device according to claim 46 further comprising filling said reflective cup with a mixture of a substantially transparent resin and at least a photoluminescent material that is capable of absorbing a portion of a first EM radiation emitted by said light-emitting element and converting said portion of said first EM radiation to a second EM radiation having a different wavelength range.

[c49] 49.A method for making an electrical device that comprises at least a light-emitting element selected from the group consisting of LED and LD, said method comprising:

(a) forming a multilayer stack, said forming comprising:

(1)providing a plurality of flexible dielectric films, each having two opposed surfaces;

(2)forming at least a circuit on at least a surface of each of said plurality of flexible dielectric films, said circuit comprising circuit traces;

(3)attaching said plurality of flexible dielectric films together with electrically insulating layers, each of said electrically insulating layers being disposed between two of said flexible dielectric films to separate circuits supported thereon; and

(4)forming a plurality of metallic vias electrically to connect at least two circuits supported on two of said plurality of flexible dielectric films;

(b)removing at least a portion of said multilayer stack through an entire thickness thereof to form at least a removed portion devoid of circuit traces;

(c)attaching at least a heat sink to an outer surface of said multilayer stack, said at least a heat sink covering said at least a removed portion; and

(d)attaching said at least a light-emitting element to said at least a heat sink in thermal contact therewith and in electrical contact with at least one of said circuit traces.

[c50] 50.The method for making an electrical device according to claim 49, wherein said step of attaching said at least a light-emitting element to said at least a heat sink comprises disposing said at least a light-emitting element in a reflective metallic cup and attaching said cup to said at least a heat sink.

[c51] 51.A method for making an electrical device that comprises at least a light-emitting element selected from the group consisting of LED and LD, said method comprising:

(a) forming a multilayer stack, said forming comprising:

(1)providing a flexible dielectric film having two opposed first and second surfaces;

(2)forming a first electrical circuit on said first surface of said flexible dielectric film;

(3)depositing a separation layer comprising an electrically insulating material on said first electrical circuit, said depositing providing an exposed surface of said separation layer;

(4)forming a second electrical circuit on said exposed surface of said separation layer;

(b)removing at least a portion of said multilayer stack through a thickness thereof to form at least a removed portion;

(c)attaching a heat sink to said second surface of said flexible dielectric film to cover said at least a removed portion; and

(d)attaching said at least a light-emitting element to said heat sink to make thermal contact therewith through said at least a removed portion.

[c52] 52.The method for making an electrical device according to claim 27 further comprising repeating steps (3) and (4) at least once before step (b).

[c53] 53.An light source comprising:

(a) a shaped structure of a thermally conductive material having a shaped surface;

(b) a flexible interconnect structure wrapped around said shaped structure in substantial contact with said shaped surface, wherein said flexible interconnect comprises:

(1)a flexible dielectric film having two opposed film surfaces, at least a portion of said dielectric film being removed through a thickness thereof, forming at least a removed portion; and

(2) circuit traces disposed on at least one of said film surfaces; and

(c)at least a light-emitting element selected from the group consisting of LED and LD attached to said shaped surface through said at least a removed portion of said dielectric film so as to be in thermal contact with said shaped structure, said at least a light emitting element being electrically connected to at least one of said circuit traces.

[c54] 54.The light source of claim 53, wherein said shaped structure has a surface selected from the group consisting of curved surfaces and surfaces that have at least a sharp corner or a sharp edge.

[c55] 55.The light source of claim 53, wherein said at least a light-emitting element is disposed in a cup having a reflective surface, said cup being attached to said shaped structure through said at least a removed portion of said dielectric film.

[c56] 56.The light source of claim 55, wherein said shaped structure is hollow.

[c57] 57.The light source of claim 56 further comprising a mechanism for active cooling, said mechanism being disposed within a cavity of said shaped structure.